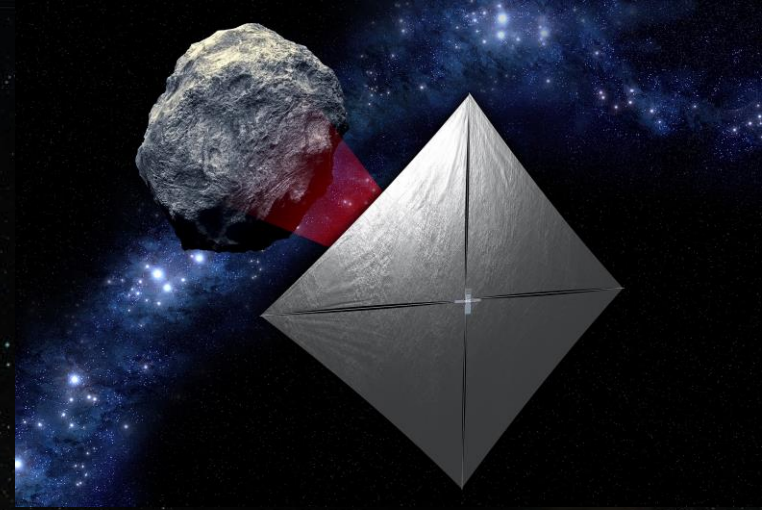


Near Earth Asteroid Scout

An Interplanetary 6U CubeSat

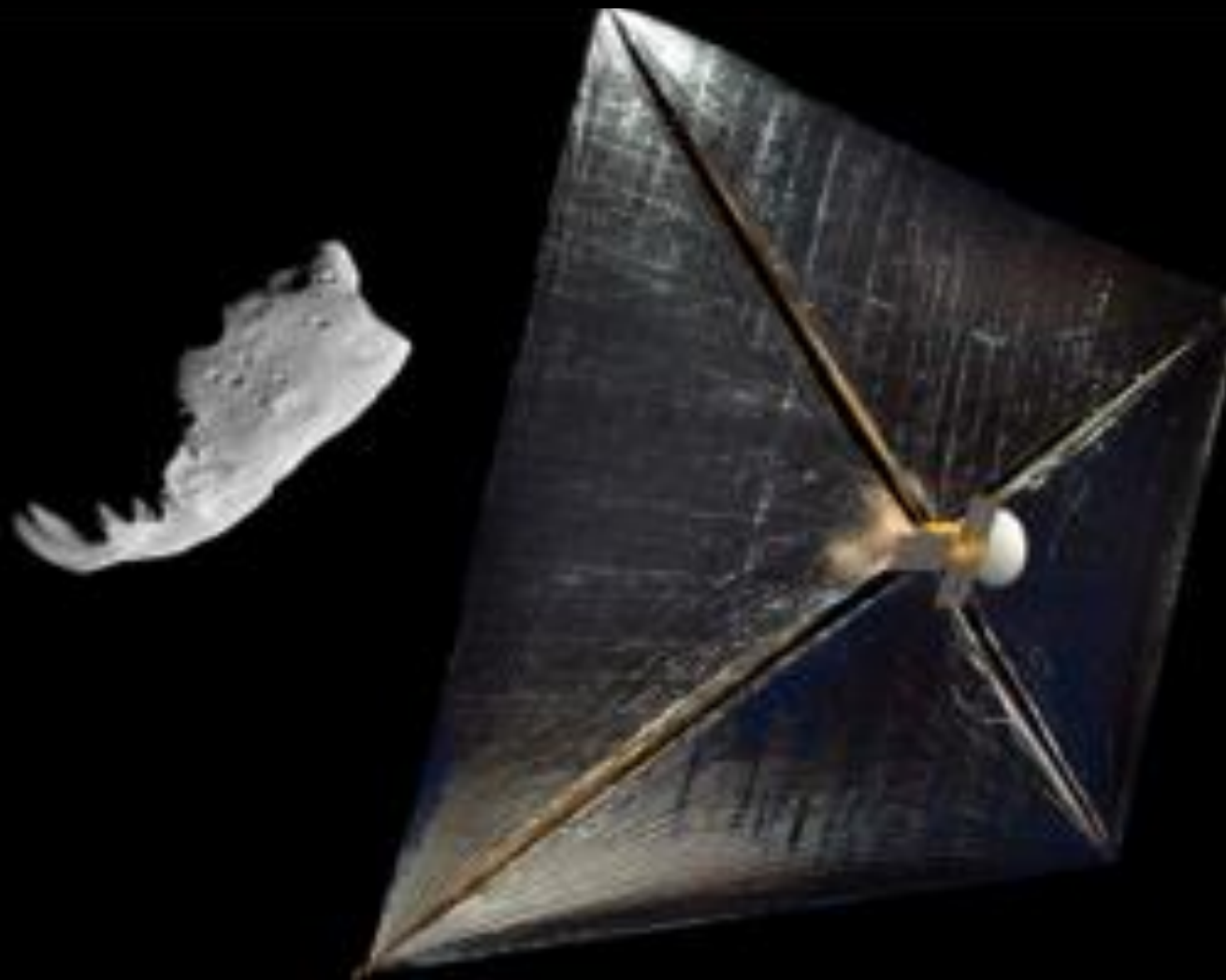
Les Johnson

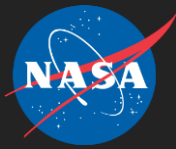
NASA MSFC



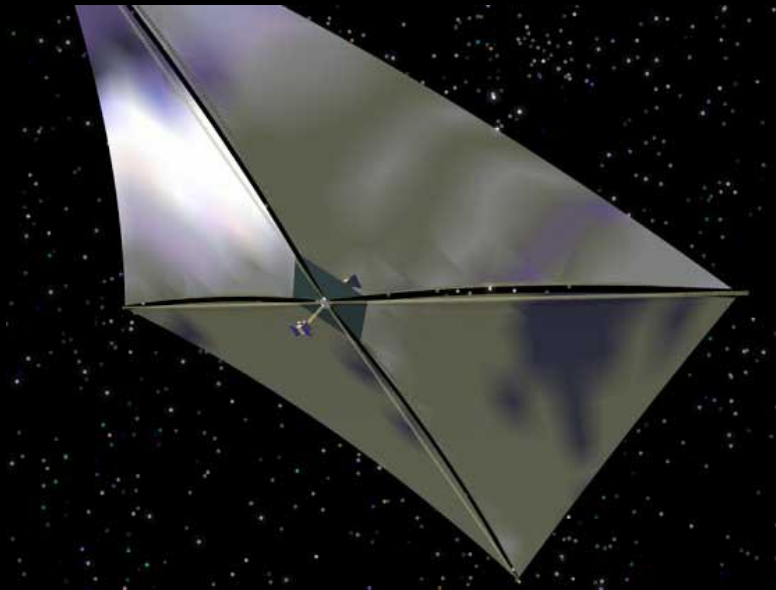


Near Earth Asteroid (NEA) Scout

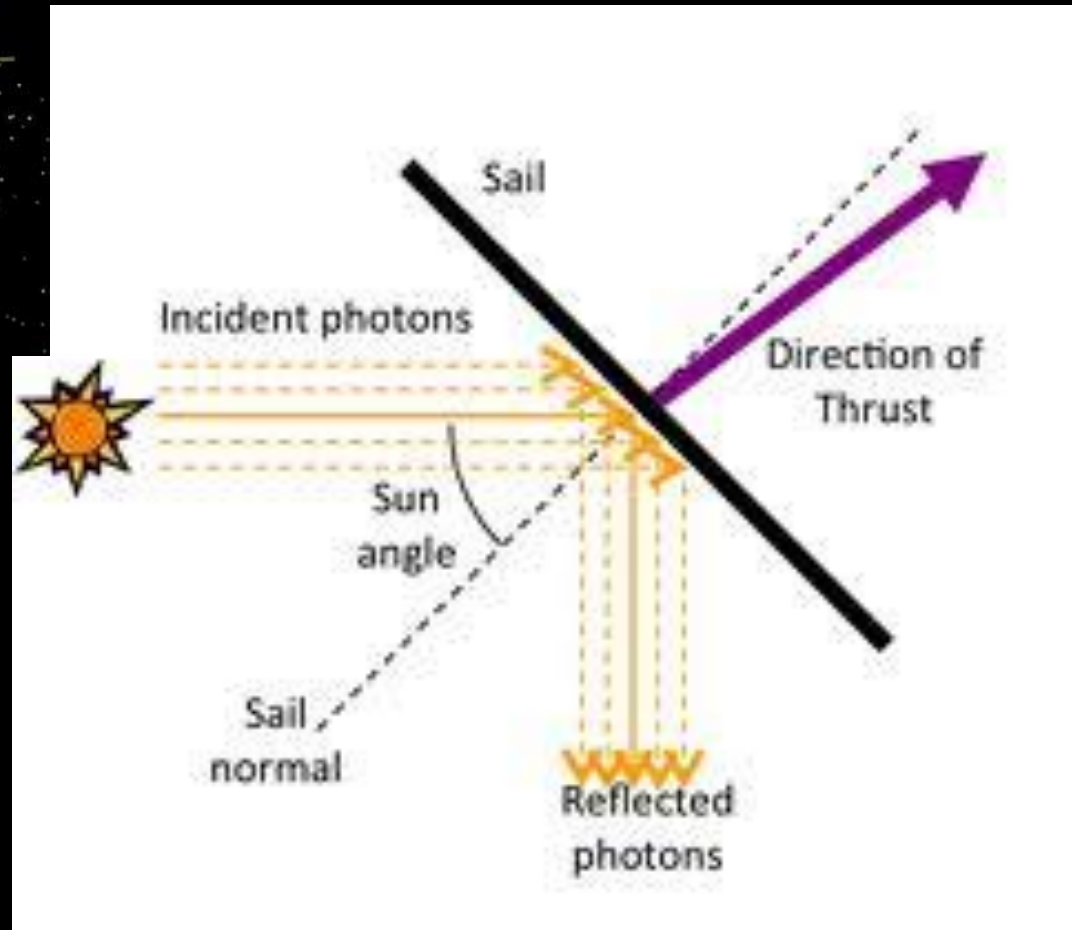




How does a solar sail work?



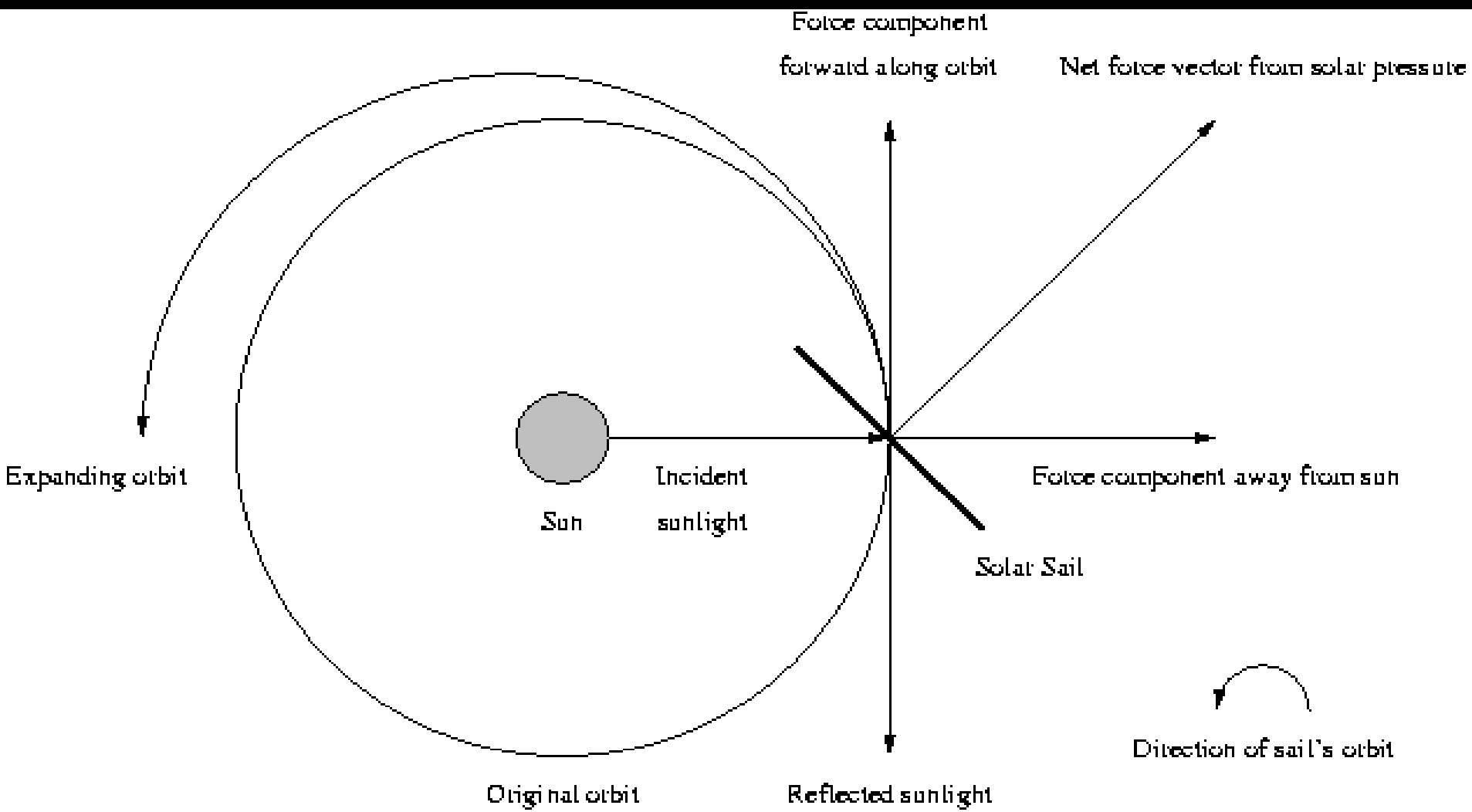
Solar sails use photon “pressure” or force on thin, lightweight reflective sheet to produce thrust.



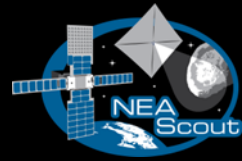


Solar sails can spiral inward or outward from the Sun

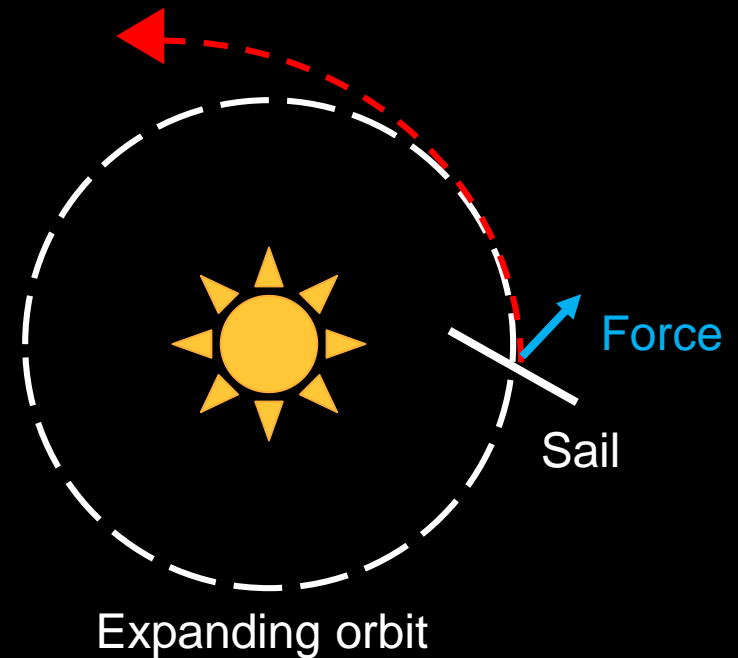
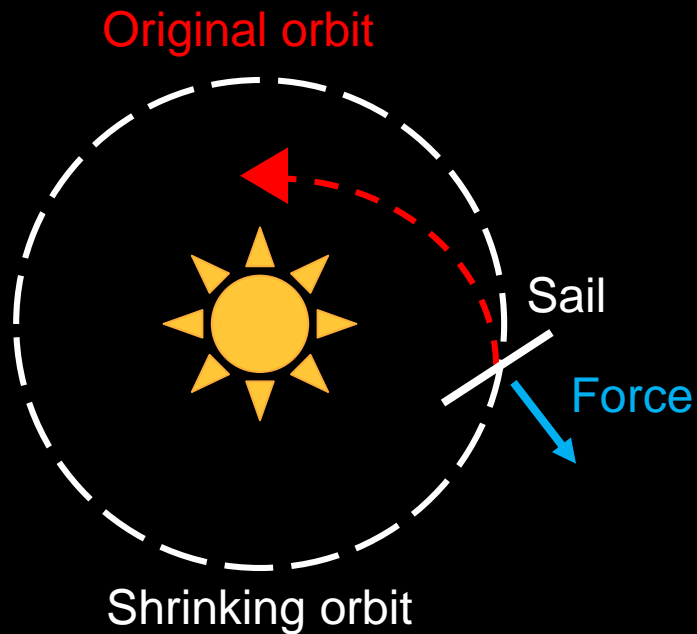
Image courtesy of Colorado Center for Astrodynamics Research



Solar Sail Trajectory Control



- Solar Radiation Pressure:
Inward and outward Spiral



Near Earth Asteroid Scout Overview

The Near Earth Asteroid Scout Will

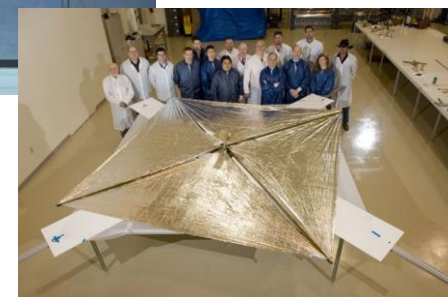
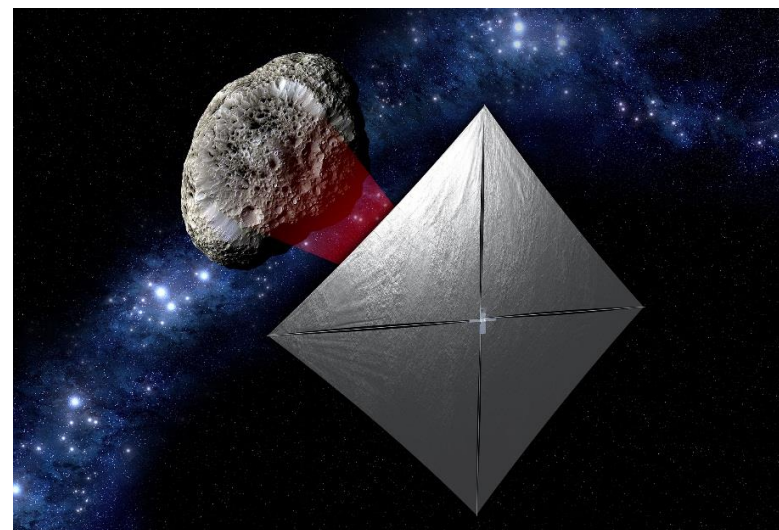
- Image/characterize an asteroid
- Demonstrate a low cost asteroid reconnaissance capability

Key Spacecraft & Mission Parameters

- 6U cubesat (20 cm X 10 cm X 30 cm)
- ~85 m² solar sail propulsion system
- Manifested for launch on the Space Launch System (EM-1/2017)
- Up to 2.5 year mission duration
- 1 AU (93,000,000 mile) maximum distance from Earth

Solar Sail Propulsion System Characteristics

- ~ 7.3 m Trac booms
- 2.5 μ aluminized CP-1 substrate
- > 90% reflectivity



NEA Scout Overview

Why NEA Scout?

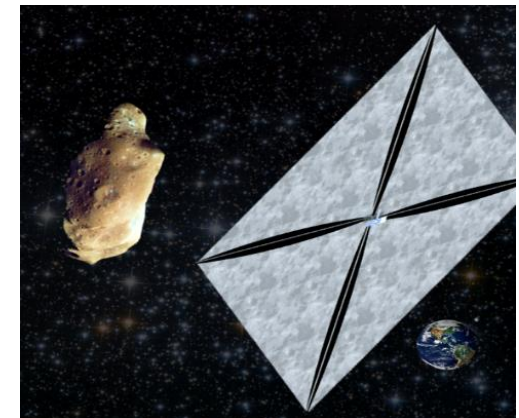
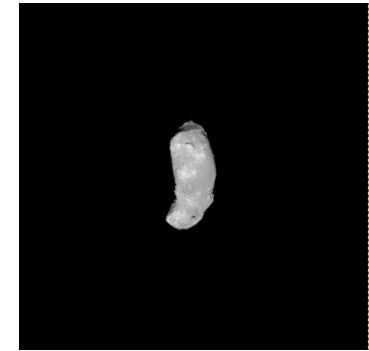
- Detect and track a Near Earth Asteroid (NEA) target
- Characterize the physical properties of the unresolved NEA target
- Flyby and characterize the physical properties of the resolved NEA target

Measurements: *NEA volume, spectral type, spin mode and orbital properties, address key physical and regolith mechanical SKG*

- $\geq 80\%$ surface coverage imaging at ≤ 50 cm/px
- Spectral range: 400-900 nm (incl. 4 color channels)
- $\geq 30\%$ surface coverage imaging at ≤ 10 cm/px

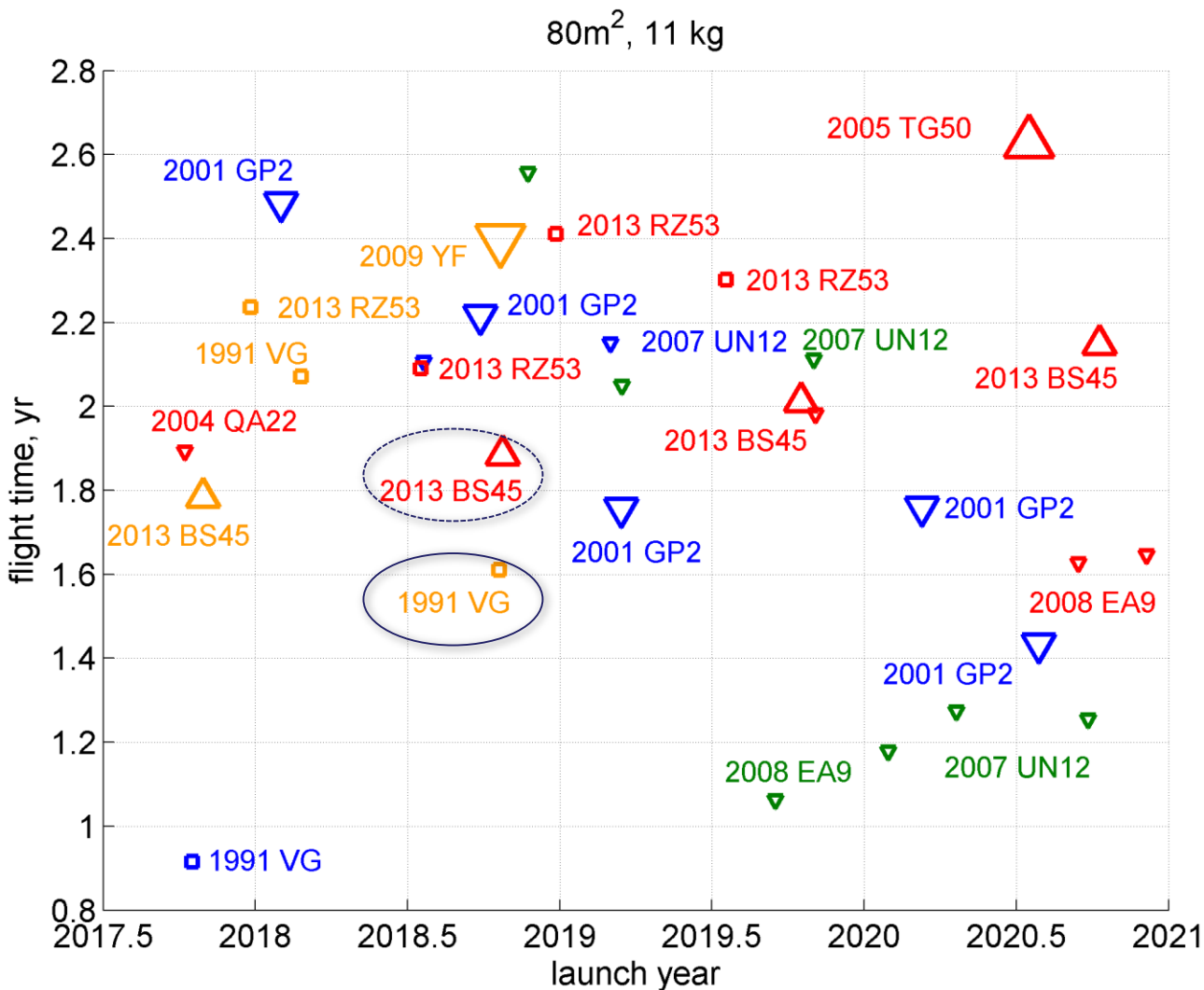
Key Technical Constraints:

- 30 month maximum mission duration
- Target must be within ~ 1 AU distance from Earth due to telecom limitations
- Slow flyby with target-relative navigation on close approach





Rendezvous Target Search



- **Telecom Distance (AU)**

- blue < .25

- green < .5

- orange < .75

- red < 1

- **OCC**

- \triangle under 2

- \square under 4

- ∇ under 7

- **Size (appx dia.)**

- small < ~15 m

- med. < ~30 m

- large < ~50 m

Local minima for flight time. Flight time increases linearly with pre-escape loiter time
Flight time increases non-linearly with delayed escapes

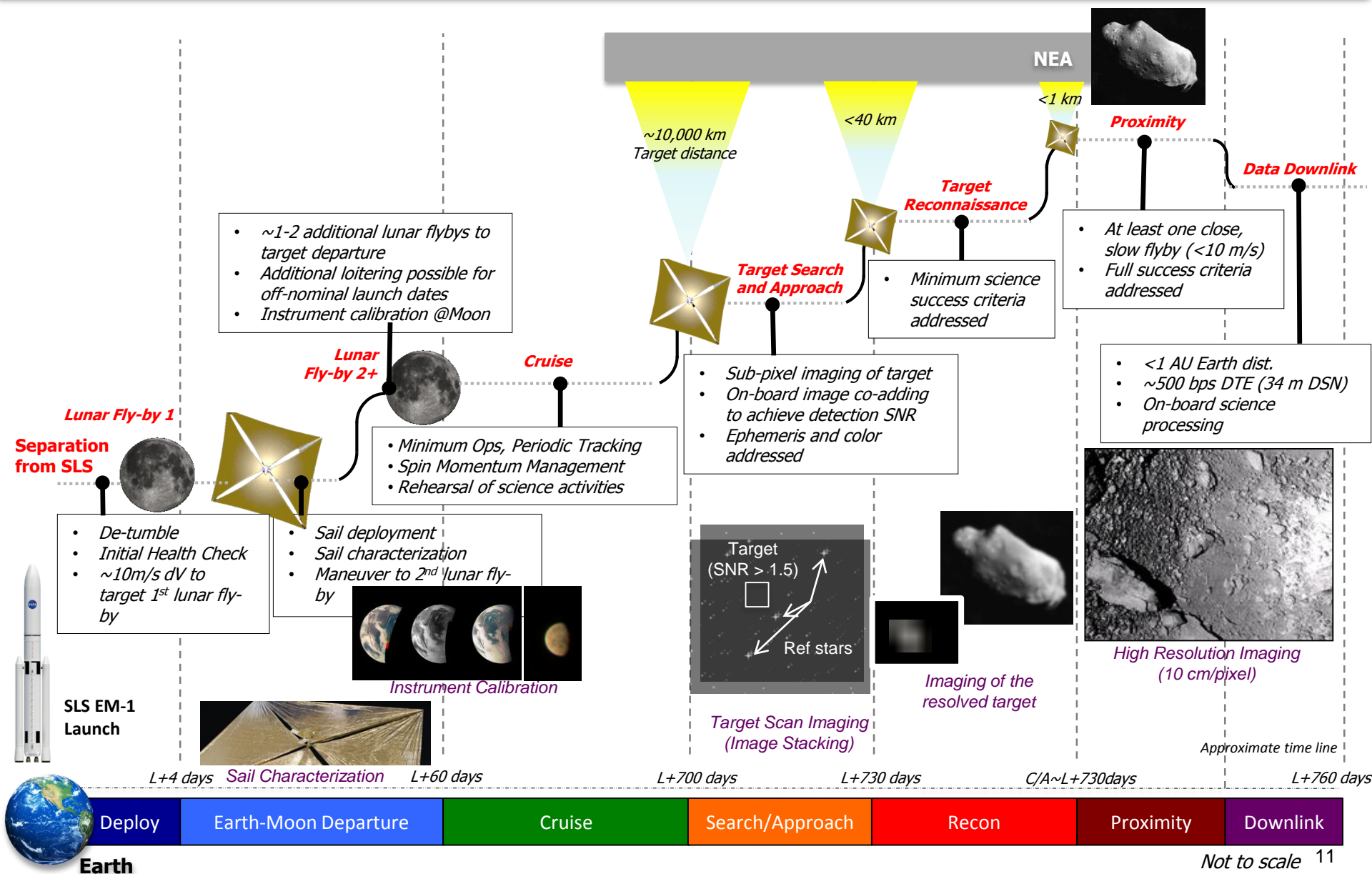
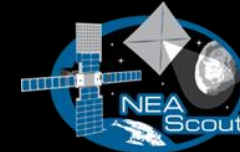
What do we Know on 1991 VG?

- Not much
- $H=28.4 \pm 0.7$
- Diameter ~ 4-17 meters
- Albedo is unknown
- Rotation period between a few minutes and less than 1 hr
- Unlikely to have a companion
- Likely did not retain an exosphere or dust cloud
 - Solar radiation pressure sweeps dust on timescales of hours or day

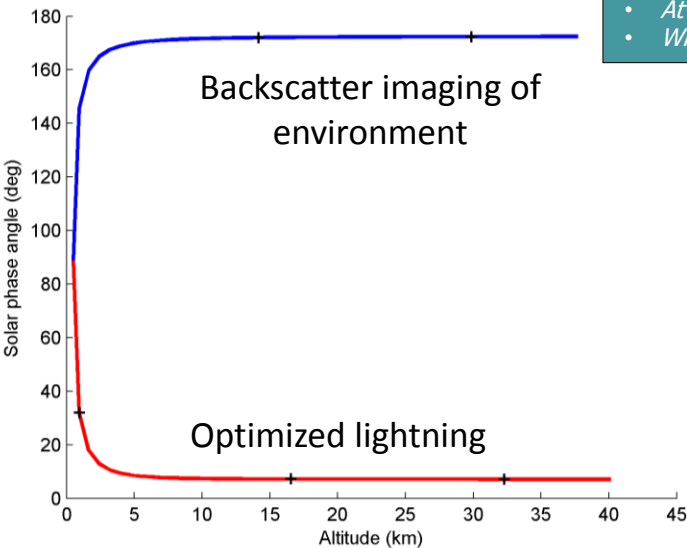
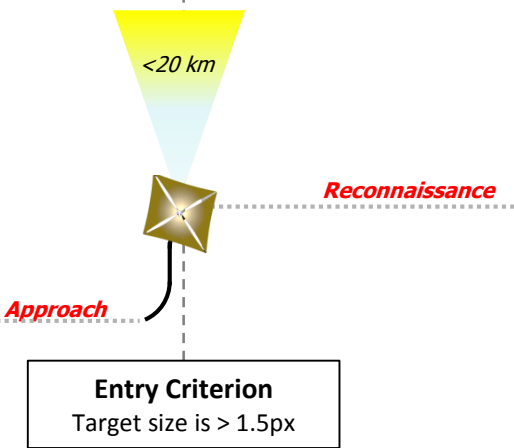




NEA Scout Operations Overview



Flyby velocity $\sim 10\text{-}20\text{m/s}$



- At least one close, slow flyby
- Wide range of solar phase angles

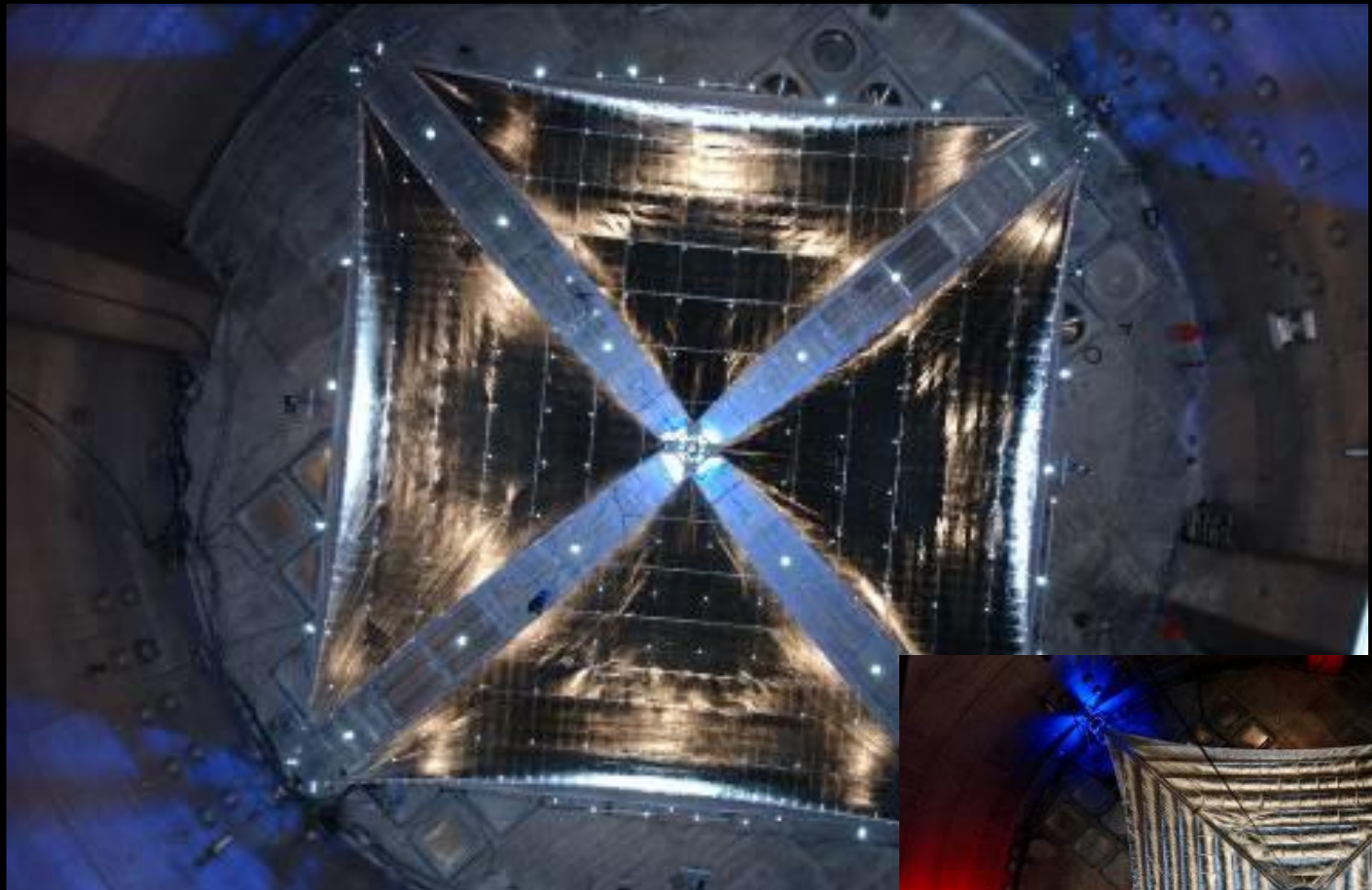
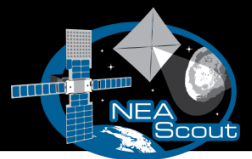


- < 0.75 AU Earth dist.
- > 500 bps DTE (34 m DSN)
- On-board science processing

Size	Rotation	Global Shape	Local Environment	Geology/Regolith
Target Reconnaissance 50 cm/px for volume, global shape, spin rate and pole position determination				Close Prox 10 cm/px for Geology

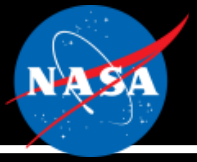


NASA Ground Tested Solar Sails



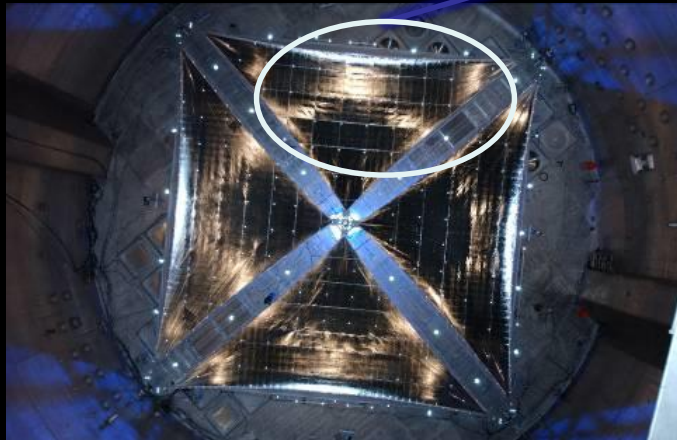


NanoSail-D Demonstration Solar Sail



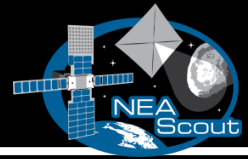
10 m² sail

Made from tested ground demonstrator hardware



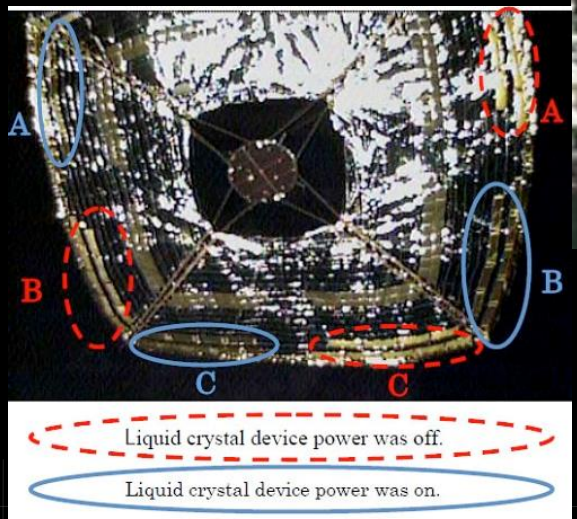
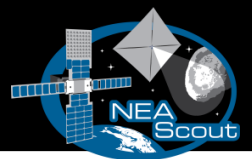


NanoSail-D in Flight



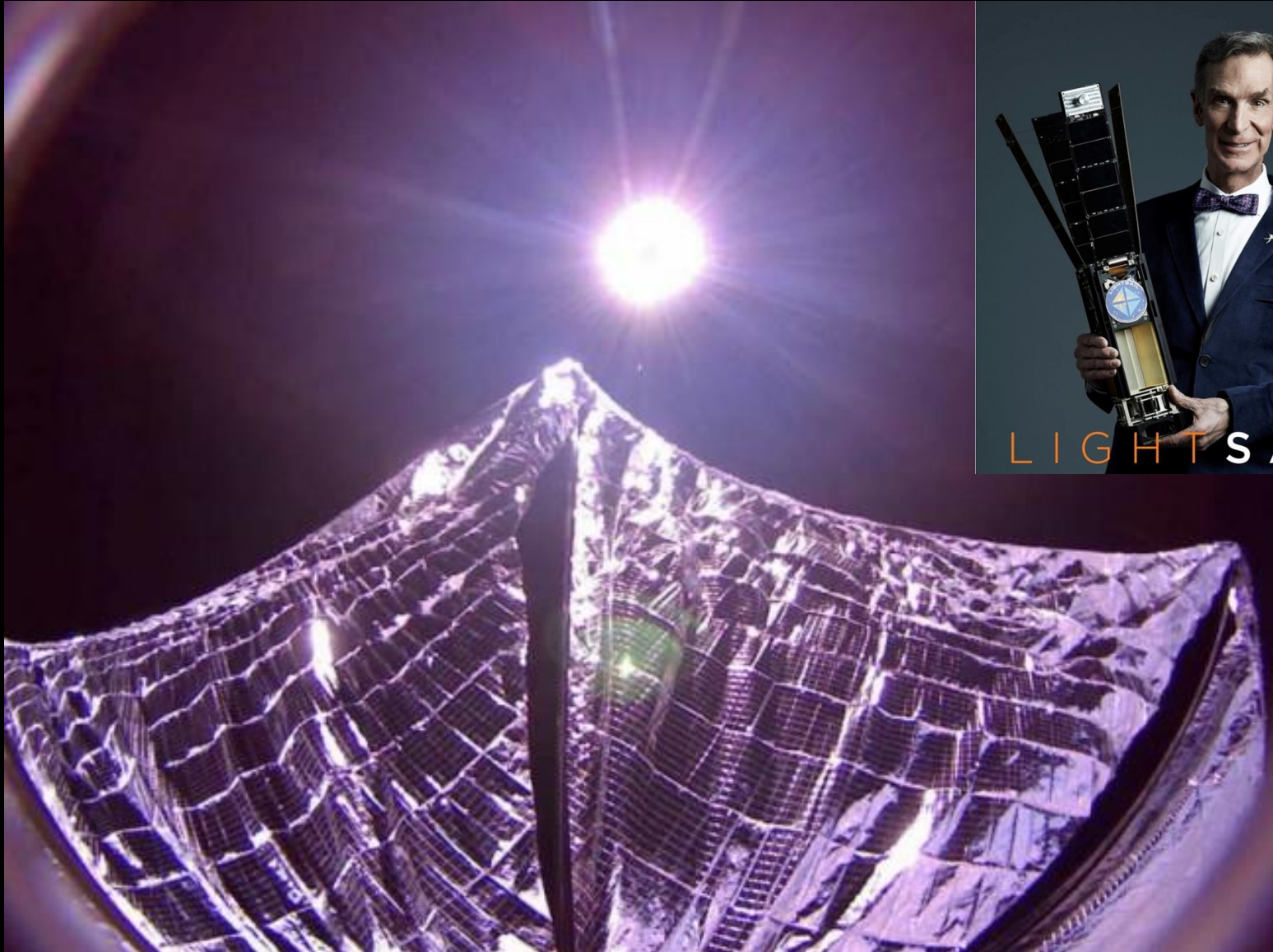


Interplanetary Kite-craft Accelerated by Radiation of the Sun (IKAROS)



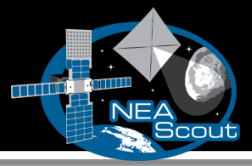


The Planetary Society's LightSail-A





NEA Scout Approximate Scale



Deployed Solar Sail



School Bus



Human



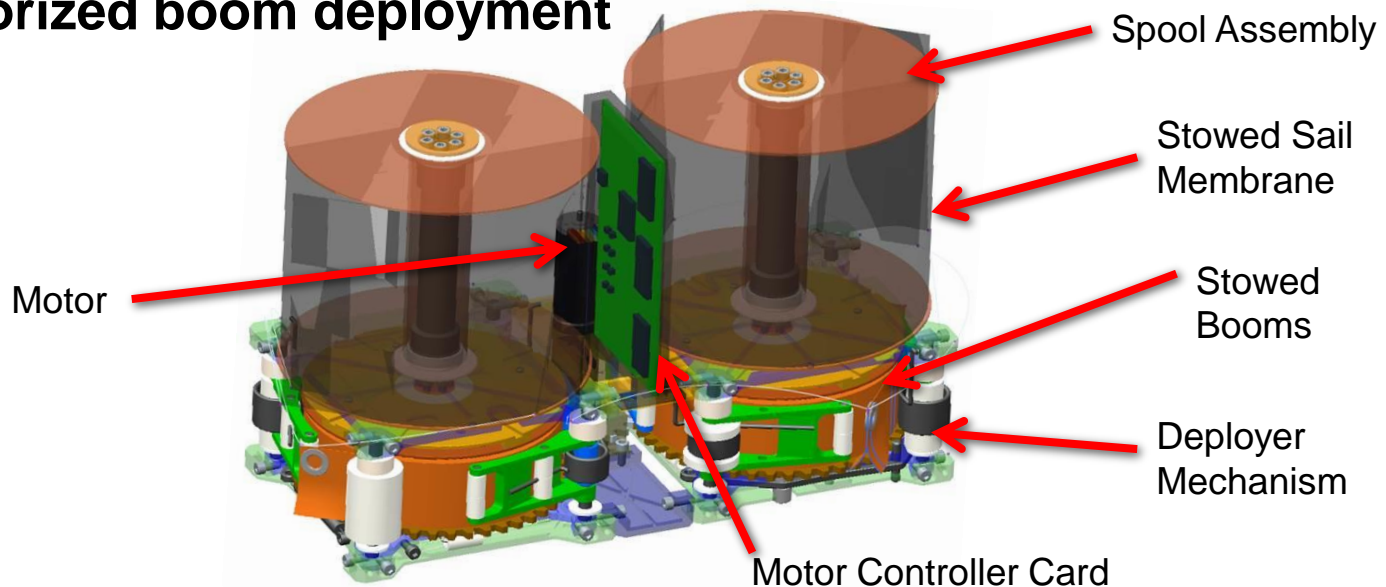
6U Stowed Flight System



Folded, spooled and packaged in here

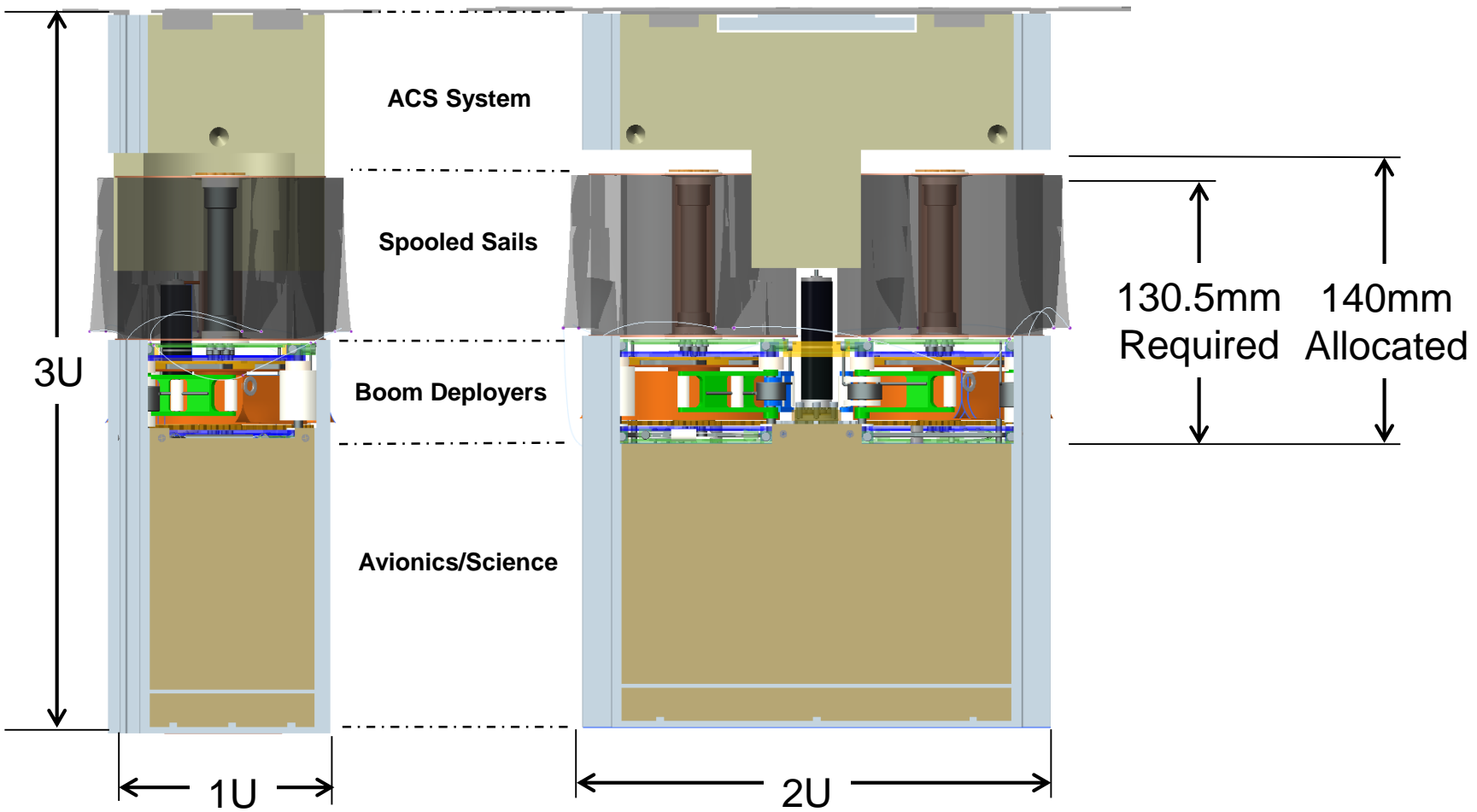
Solar Sail Mechanical Description

- 4 quadrant sail
- 85 m² reflective area
- 2.5 micron CP1 substrate
- Z folded and spooled for storage
 - 2 separate spools with 2 sail quadrants folded onto each
- 4 7-meter stainless steel TRAC booms coiled on a mechanical deployer
 - 2 separate deployers and each deployer releases 2 TRAC booms
 - Motorized boom deployment





Solar Sail Volume Envelope

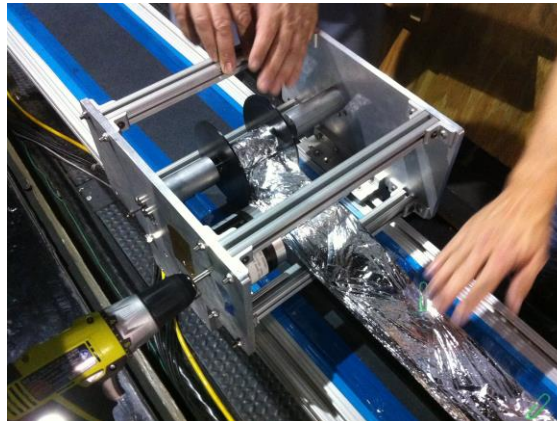
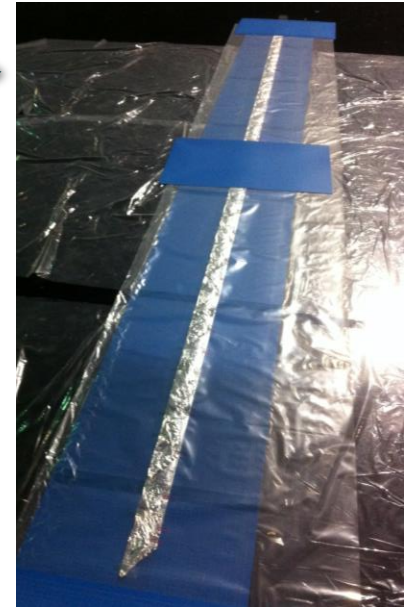
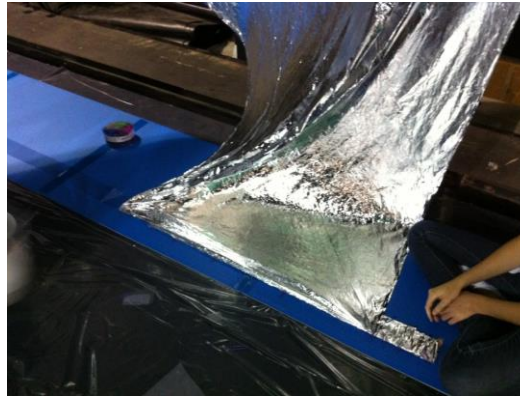
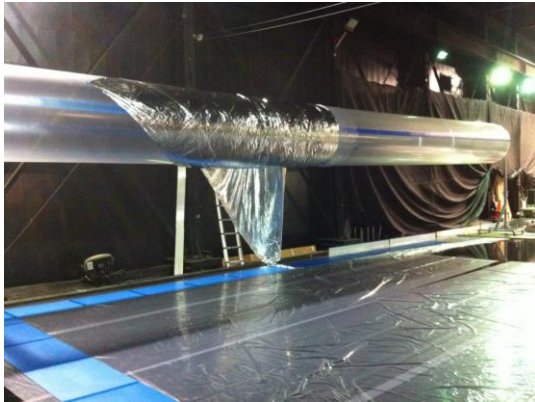


Sail Packing Efficiency

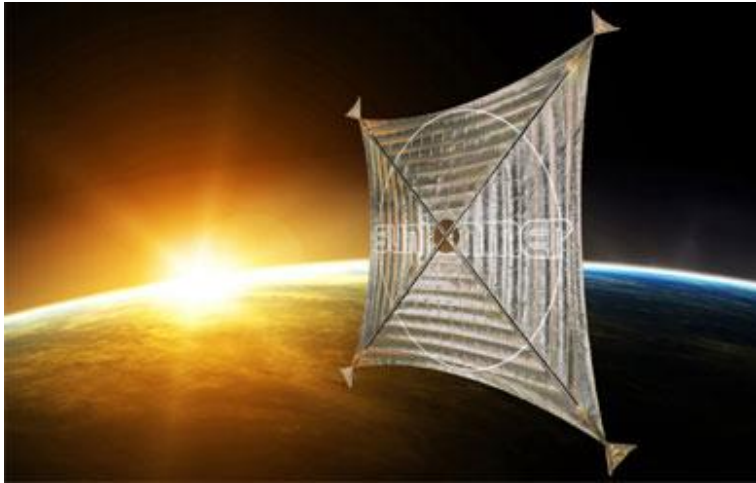
Calculated Value:

- Fabricated 2 flight size 10m sails from existing 20m CP1 sail.
- Z-folded and spooled 2 sail quadrants onto the hub.
- Calculated new packing efficiency to be **27.5 %** →

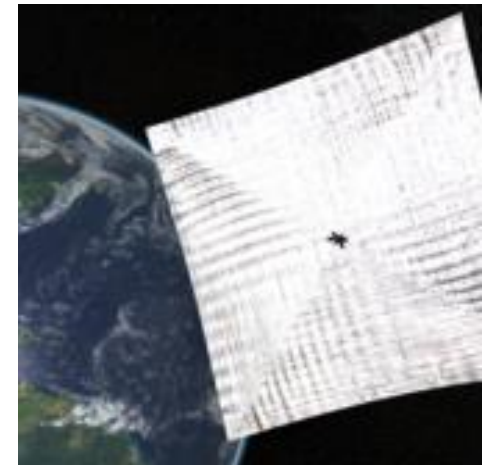
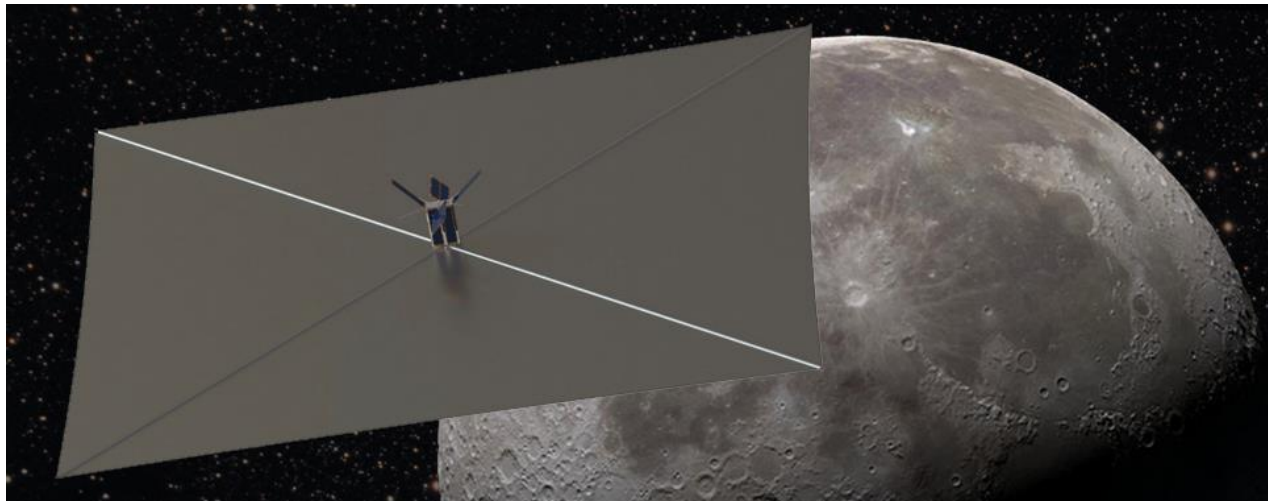
Higher percentage results in tighter packaging and thus more volume margin for design space.



Planned CubeSat Solar Sail Missions



- NASA's *NEA Scout* and *Lunar Flashlight*
- The Planetary Society's *LightSail-A* and *LightSail-B*
- The University of Surrey's *CubeSail*, *DeorbitSail*, and *InflateSail*
- ESA and DLR's *Gossamer 1* and *Gossamer-2*





Near Earth Asteroid (NEA) Scout

